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(71)Applicant : SHOWA ALUM CORP

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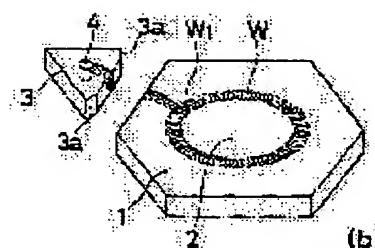
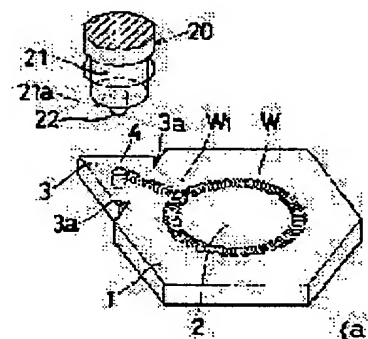
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## (54) FRICTION STIRRING JOINING METHOD

## (57)Abstract:

PROBLEM TO BE SOLVED: To provide a method causing no holes or recesses after a probe is pulled out in a friction stirring joining method for joining members having such parts to be joined as the ending part returns to the starting part.

SOLUTION: A rotating probe 22 is inserted into a part to be joined of members 1, 2 and moved along the joining part with the probe 22 inserted while the part in contact with the probe is softened by frictional heat and stirred. When the probe 22 returns to the starting part W1 of joining, it is made to change in the moving direction and moved to the part 3 to be discarded that is provided at a position other than the joining part of the members 1, 2. Then, the probe 22 is pulled out of the part 3 to be discarded, with the part 3 cut off and removed.



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CLAIMS

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## [Claim(s)]

[Claim 1] Inserting the rotating probe (22) in the aforementioned joint in the joint material (1) which has a joint (A) from which a trailer returns to a leader, and (B), (2), (7), and (8), softening the contact section with a probe in frictional heat, and agitating By moving a probe (22) relatively along with the aforementioned joint in the state of insertion The friction churning conjugation method characterized by the thing by which the move direction was changed and the probe (22) of the aforementioned insertion state was formed in positions other than the joint of the aforementioned joint material in the friction churning conjugation method which joins the aforementioned joint material at the time of a junction end, and which you throw away and is made to move to the meat section (3) and (9).

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[Translation done.]

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## DETAILED DESCRIPTION

## [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the friction churning conjugation method used for junction of metal material, such as for example, aluminum material (aluminium alloy material is included).

[0002]

[Description of the Prior Art] The disc-like 2nd joint material (52) of metal is fitted into a hole (51a), for example, as shown in drawing 5, it was prepared in the center of the 1st joint material (51) of metal of the tabular formed in the hexagon — circular — When continuing and joining the 1st joint material (51) and the 2nd joint material (52) to the perimeter of the fitting section (A'), the friction churning conjugation method which is one of the solid phase conjugation methods may be used.

[0003] It will be as follows if this friction churning conjugation method is explained. That is, the aforementioned probe (62) is inserted in a part of fitting section (A') of the 1st joint material (51) and the 2nd joint material (52), rotating the aforementioned rotator (61) using the junction tool (60) which the pin-like probe (62) of \*\*\*\* projected and was formed on the edge axis of the pillar-like rotator (61) of path size at one, as shown in drawing 5 (b). Generally, insertion is performed until the shoulder (61a) which consists of a probe side flat side of a rotator (61) contacts both joint material (51) and (52).

[0004] And as shown in drawing 6 (a), along with the fitting section (A'), a probe (62) is relatively moved to both joint material (51) and (52) with a probe insertion state. With the frictional heat generated by rotation of a probe (62), or the frictional heat further generated with the shoulder (61a) of a rotator (61), and sliding with both joint material (51) and (52) While softening both joint material (51) and (52) [ near the contact portion with a probe (62) ] and being agitated by the probe (62) After carrying out a plastic flow with movement of a probe (62) in the mode around which it turns behind [ travelling-direction ] a probe (62) so that a softening churning portion may fill the passage slot on the probe in response to the advance pressure of a probe (62), frictional heat is lost quickly and cooling solidification is carried out. This phenomenon is successively repeated with movement of a probe (62), and, finally both joint material (51) and (52) are joined in the fitting section (A'). In this drawing, (W') is the junction bead section formed of this friction churning junction, and is formed along with the fitting section (A').

[0005] According to such a friction churning conjugation method, since it is solid state welding, it is not limited to the kind of metal material which is joint material, or there is an advantage, like there is little deformation by the heat distortion at the time of junction.

[0006] By the way, since it is not necessary to join any more if a probe (62) returns to the junction leader (W1') in the fitting section (A') when carrying out friction churning junction of the above-mentioned joint material (51) and (52), as it \*\* to this drawing (b), you have to draw out a probe (62) from joint material (51) and (52).

[0007]

[Problem(s) to be Solved by the Invention] However, if a probe (62) is drawn out from the front face of joint material (51) and (52) to shaft orientations, the hole (53) corresponding to the path of a probe (62) and the immersion depth will surely remain in the junction trailer of the fitting section (A'). Since this hole (53) is that to which a bonding strength is reduced locally, it must remove or bury this after a junction end.

[0008] this hole — the method of filling up a hole (53) with molten metal as a processing means by melting welding of the method of embedding a pin at a hole (53), TIG, MIG, etc., etc. is proposed However, since the method embedding a pin only fixes a pin by mechanical penetrating, it is deficient in reliability on the strength. Moreover, the method by melting welding has problems, like the fall of a bonding strength and heat distortion arise with the welding heat generated at the time of welding.

[0009] In addition, when carrying out friction churning junction of the joint material which has a joint from which a trailer does not return to a leader, for example, a straight-line-like joint, after attaching a weld tab in the trailer of a joint, the method of making move a probe (62) to a weld tab, and subsequently removing this weld tab is effective, although not illustrated. as [ described / this method / however, / above ] — turning — junction — or since a trailer does not exist in /, such as periphery junction, / joining the joint material (51) which has a joint from which a trailer returns to a leader (W1'), and (52), this is inapplicable

[0010] Idea \*\* changing the move direction and drawing out the probe (62) of the insertion state which has returned to the junction leader (W1') from the end face of the 1st joint material (51) moreover, in this case Since a crevice (not shown) will be formed in the end face of the 1st joint material (51) as drawing marks of a probe, the problem that the appearance of the junction article obtained becomes bad arises.

[0011] This invention was made in order to solve such a problem, and it aims at offering the friction churning conjugation method which does not produce the hole or crevice after probe drawing in the friction churning conjugation method which joins the joint material which has a joint from which a trailer returns to a leader.

[0012]

[Means for Solving the Problem] This invention inserting the rotating probe in the aforementioned joint in the joint material which has a joint from which a trailer returns to a leader, softening the contact section with a probe in frictional heat, and agitating, in order to attain the above-mentioned purpose By moving a probe relatively along with the aforementioned joint in the

state of insertion In the friction churning conjugation method which joins the aforementioned joint material, it is characterized by the thing by which the move direction was changed and the probe of the aforementioned insertion state was formed in positions other than the joint of the aforementioned joint material at the time of a junction end and which you throw away and is made to move to the meat section.

[0013] The direction [ according to this / the time of a junction end / the move direction of a probe ] by changing the move direction of the probe of an insertion state, i.e., shift from a junction line., where a joint is prolonged And if this probe is thrown away and it is made to advance into the meat section, it throws away, and the amount of [ with the probe in the meat section ] contact softened zone will carry out a plastic flow to back, and the slot produced after passage of a probe will be filled. Subsequently, the probe of an insertion state which threw away and moved to the meat section is thrown away, and is drawn out from the meat section. By carrying out like this, it becomes impossible for the hole after probe drawing to remain in a joint therefore, the fall of the bonding strength of a joint can be prevented, and the reliability of a joint on the strength also improves. Then, by throwing away and removing the meat section further, the fall of the appearance appearance of the junction article which the hole and crevice after probe drawing stop remaining in joint material therefore, and is produced by the hole and crevice after probe drawing can be prevented, therefore the appearance of a junction article can be maintained now.

[0014] It is the point which a probe can throw [ being prepared near / near the trailer of a joint (i.e., a leader) /, although it is good anywhere if it throws away here and the meat section is prepared in positions other than a joint ] away, can shorten the travel to the meat section, can throw away a probe promptly, and can be moved to the meat section, consequently can raise junction working capacity now, and is desirable.

[0015]

[Embodiments of the Invention] Drawing 1 and drawing 2 show one operation gestalt (the 1st operation gestalt) of this invention. In this drawing, the 1st joint material of the tabular by which (1) was formed in the hexagon, and (2) are the disc-like 2nd joint material. the [ these / 1st / and ] — both 2 joint material (1) and (2) consist of aluminum

[0016] it penetrated in the thickness direction like the 1st joint material (51) explained to the center section of the aforementioned 1st joint material (1) with the above-mentioned conventional technology — circular — the hole (1a) is prepared this 1st joint material (1) of the 1st operation gestalt shown in this drawing is circular as well as the above-mentioned conventional technology — the aforementioned 2nd joint material (2) is fitted into a hole (1a), and the case where cover the perimeter of the fitting section (A) and friction churning junction of the 1st joint material (1) and the 2nd joint material (2) is carried out is shown in it — it is . Therefore, the fitting section (A) turns into a joint of both joint material (1) and (2). In addition, the thickness of the 1st joint material (1) and the 2nd joint material (2) is the same, and the 1st joint material (1) is circular — in the state where the 2nd joint material (2) was fitted into the hole (1a), the front face of the 1st joint material (1) and the front face of the 2nd joint material (2) are flat-tapped

[0017] (20) is a junction tool, on the edge axis of the pillar-like rotator (21) of path size, the pin-like probe (22) of \*\*\*\* projects, it is prepared at one, and high-speed rotation of the probe (22) is carried out by carrying out high-speed rotation of the rotator (21). In addition, the probe (22) and the rotator (21) are formed with the heat-resisting material which can bear the frictional heat which is hard and is generated from joint material (1) and (2) at the time of junction.

[0018] The tabular formed in the shape of a triangle throws away into the end edge of the aforementioned 1st joint material (1), and the meat section (3) protrudes on one. this — it throws away and the meat section (3) mentions later — as — the 1st joint material (1) — drawing of a probe (22) — it is for not leaving a hole or a crevice and carrying out them, and the thickness is the same as the thickness of the 1st joint material (1), and that of the front face and front face of the 1st joint material (1) is flat-tapped Moreover, the V character-like infeed section (3a) (3a) can prepare and throw away into connection section edges on both sides with this 1st joint [ in / the meat section (3) / it throws away and ] material (1), and the meat section (3) can be easily removed now to them.

[0019] Friction churning junction according to this invention is performed as follows. That is, the probe (22) which this and really rotates is inserted in the fitting section (A) by rotating a rotator (21). And making the flatness-like shoulder (21a) at the nose of cam of a rotator (21) contact the front face of joint material (1) and (2) in the state of probe insertion While being able to prevent scattering of the material for a softened zone in the middle of the time of a junction start, or junction and being able to realize a uniform junction state It is desirable from the point of making frictional heat produce further by sliding with joint material (1), (2), and a shoulder (21a), promoting the contact section with a probe, or softening of the near, and preventing concavo-convex formation of the front face of joint material (1) and (2) further.

[0020] And along with the fitting section (A), a probe (22) is relatively moved with a probe insertion state. With the frictional heat generated by rotation of a probe (22), or the frictional heat further generated with sliding with the shoulder (21a) of a rotator (21), and the front face of joint material (1) and (2) While softening joint material (1) and (2) and being agitated [ near the contact portion with a probe (22) ] After carrying out a plastic flow with movement of a probe (22) in the mode around which it turns behind [ travelling-direction ] a probe (22) so that a softening churning portion may fill the passage slot on the probe (22) in response to the advance pressure of a probe (22), frictional heat is lost quickly and cooling solidification is carried out. This phenomenon is successively repeated with movement of a probe (22), in the fitting section (A), it is unified and both joint material (1) and (2) are joined one by one. In addition, in drawing 1 (a), (W) is the junction bead section formed of this friction churning junction, and is formed along with the fitting section (A).

[0021] And since it means that both joint material (1) and (2) were continued and joined to the perimeter of the fitting section (A) when the probe (22) of an insertion state has returned to the junction leader (W1) in the fitting section (A), although it becomes a junction end If a probe (22) is drawn out from the front face of joint material (1) and (2) by this probe insertion point, as the above-mentioned conventional technology explained, a probe will draw out and a hole will arise. Then, as the move direction of a probe (22) is changed and it is shown in drawing 1 (b), a probe (22) is thrown away with an insertion state and moved to the meat section (3). Thus, when a probe (22) throws away and it advances into the meat section (3), it throws away, and the amount of [ with the probe (22) in the meat section (3) ] contact softened zone will carry out a plastic flow behind [ travelling-direction ] a probe (22), and it will fill the slot produced after passage of a probe (22). Therefore, neither a hole nor a crevice remains in the fitting section (A), i.e., a joint.

[0022] Subsequently, the probe (22) which threw away in this way and moved to the meat section (3) is thrown away, and is drawn out from the front face of the meat section (3) to shaft orientations. then, it is shown in drawing 2 (a) — as — drawing of a probe — since a hole (4) will throw away and it will be formed in the meat section (3), it is shown in this drawing (b) — as — this — it throws away, the meat section (3) is cut deeply, and cutting removal is carried out in the section (3a) (3a) By carrying out like this, it becomes impossible for a hole and a crevice to remain on the remains of probe passage in joint material (1) and (2) therefore, and a junction state can obtain a good junction article.

[0023] in addition, the probe (22) which threw away and moved to the meat section (3) although not illustrated — throwing away — from the end face of the meat section (3) — drawing out — subsequently — the — it may throw away and the meat section (3) may be removed

[0024] Moreover, by throwing away, forming the slot for fracture (not shown) in the connection section with the 1st joint material (1) in the meat section (3) beforehand, throwing away, and fracturing the meat section (3) in this slot, it may throw away and the meat section (3) may be removed. By carrying out like this, like the above-mentioned 1st operation gestalt, it can throw away and the meat section (3) can be removed easily.

[0025] Drawing 3 and drawing 4 show another operation gestalt (the 2nd operation gestalt) of this invention. This 2nd operation gestalt shows the case where the member for suspension arms of an automobile is manufactured, by the junction performed in accordance with the periphery of two joint material (7) which has a circular cross section, and (8), i.e., periphery junction.

[0026] First, this member for suspension arms is explained. this drawing — setting — (8) — the member of the member for suspension arms — circular bush wearing for a main part (the 2nd joint material) and (7) carrying out pressing wearing of the vibrationproofing bush (not shown) — it is the bush carrying member (the 1st joint material) which has a hole (5a) the above — a member — a main part (8) consists of cylindrical aluminum extrusion cylinder pipe material which has predetermined length (8a) is the centrum of pipe material. moreover, the aforementioned bush carrying member (7) — from an aluminum forging — becoming — the aforementioned bush wearing — the pillar-like connection section (6) protrudes on a part of peripheral face of the body (5) equipped with the hole (5a) at one the path of the aforementioned connection section (6) — the above — a member — it is the outer diameter and this \*\* of a main part (8) and this member for suspension arms is shown in drawing 3 — as — the above — a member — the end face of the connection section (6) of the aforementioned bush carrying member (7) is compared to the end side of a main part (8), and it is shown in drawing 4 — as — a member — it is manufactured by comparing a main part (8) and bush carrying member (7), covering the perimeter of the section (B) and carrying out friction churning junction therefore, the matching section (B) — a member — it becomes a main part (8) and the joint of bush carrying member (7) in addition, a member — the state where the end face of the connection section (6) was compared to the end side of a main part (8) — setting — a member — the peripheral face of a main part (8) and the peripheral surface of the connection section (6) are flat-tapped

[0027] Moreover, it becomes a part of peripheral surface of the connection section (6) of the aforementioned bush carrying member (7) from the heights which have predetermined length by the shape of a cross-section triangle, and throws away, and the meat section (9) protrudes on one. this — it throws away and the whole surface of the meat section (9) is as flat-tapped as the peripheral surface of the connection section (6)

[0028] this 2nd operation gestalt — friction churning junction — the above-mentioned 1st operation gestalt and abbreviation — it is as follows, when it is performed by the same procedure and this is briefly explained focusing on the difference with the 1st operation gestalt

[0029] That is, it compares rotating the probe (22) of the aforementioned junction tool (20), and inserts in the section (B) from the peripheral face. and a probe (B) — an insertion state — comparing — the section (B) — meeting — a member — it is made to move relatively [ hoop direction / of a main part (8) and the connection section (6) ] With this movement, as shown in drawing 4 (a), the matching section (B) is joined one by one. In this drawing, (W) is the junction bead section formed of this friction churning junction, and is formed along with the matching section (B).

[0030] And when the probe (22) of an insertion state compares and it has returned to the junction leader (W1) in the section (B), as the move direction of a probe (22) is subsequently changed and it is shown in this drawing (b) from a junction end and a bird clapper, a probe (22) is thrown away with an insertion state and moved to the meat section (9). And this probe (22) is thrown away and it draws out from the front face of the meat section (9) to shaft orientations. In addition, although not illustrated, a probe (22) may be thrown away and you may draw out from the end face of the meat section (9). In this way, when a probe (22) is thrown away and it draws out from the meat section (9), it will throw away, a probe will draw out in the meat section (9), and a hole (9) and a crevice (not shown) will be formed. and — this — it throws away and cutting removal of the meat section (9) is carried out carrying out like this — bush carrying member (7) and a member — it becomes impossible for a hole and a crevice to remain on the remains of probe passage in a main part (8) therefore, and a junction state can obtain a good junction article, i.e., the member for suspension arms

[0031] the [ as mentioned above, / of this invention / the 1st and ] — although 2 operation gestalten were explained, this invention is not limited to these operation gestalt

[0032] the [ for example, / the above 1st and ] — with 2 operation gestalten, it throws away and the meat section (3) and (9) are beforehand prepared in joint material (1) and (7) at one — although it comes out, and not illustrated, it throws away, the meat section is prepared separately and this may be attached in joint material Adhesion and forcing using adhesives as this anchoring means are employable.

[0033]

[Effect of the Invention] This invention inserting the rotating probe in the aforementioned joint in the joint material which has a joint from which a trailer returns to a leader, softening the contact section with a probe in frictional heat, and agitating by above-mentioned order By moving a probe relatively along with the aforementioned joint in the state of insertion In the friction churning conjugation method which joins the aforementioned joint material at the time of a junction end the probe of the aforementioned insertion state Since it is characterized by the thing by which the move direction was changed and it was prepared in positions other than the joint of the aforementioned joint material and which you throw away and is made to move to the meat section, according to the friction churning conjugation method concerning this invention The slot which is thrown away

and produced after passage of a probe by part for a contact softened zone with the probe in the meat section is filled, and things are made. Therefore, even if it is the case where the joint material which has a joint from which a trailer returns to a leader is joined by the friction churning conjugation method, the hole or crevice after probe drawing cannot remain in a joint, that is, the bonding strength of a joint can obtain a high junction article with the high reliability on the strength to it. Furthermore, after throwing away and drawing out a probe from the meat section, by [ this ] throwing away and removing the meat section, the hole or crevice after probe drawing cannot remain in joint material, that is, the good junction article of appearance can be obtained to it.

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DESCRIPTION OF DRAWINGS

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## [Brief Description of the Drawings]

[Drawing 1] It is drawing showing one operation gestalt (the 1st operation gestalt) of this invention, and is a perspective diagram in the state where (a) threw away the perspective diagram of the state in the middle of junction, (b) threw away the probe, and it was made to move to the meat section.

[Drawing 2] It is drawing showing this operation gestalt, and they are a perspective diagram in the state where (a) threw away the probe and it drew out from the meat section, and a perspective diagram in the state where (b) threw away and cutting removal of the meat section was carried out.

[Drawing 3] It is the perspective diagram of the state before the junction which shows another operation gestalt (the 2nd operation gestalt) of this invention.

[Drawing 4] It is drawing showing this operation gestalt, and is a perspective diagram in the state where (a) threw away the perspective diagram of the state in the middle of junction, (b) threw away the probe, and it drew out from the meat section.

[Drawing 5] It is drawing showing the conventional friction churning junction, and (a) is the perspective diagram of the state before two fitting of joint material, and (b) is the perspective diagram of the state after two fitting of joint material.

[Drawing 6] It is drawing showing the fault of the conventional friction churning junction, and (a) is the perspective diagram of the state in the middle of junction, and (b) is the perspective diagram of the state after junction.

## [Description of Notations]

1 2 — Joint material

3 — It throws away and is the meat section.

4 — probe drawing — a hole

7 — Bush carrying member of the member for suspension arms (joint material)

8 — a member — a main part (joint material)

9 — It throws away and is the meat section.

10 — probe drawing — a hole

20 — Junction tool

22 — Probe

A — Fitting section (joint)

B — Matching section (joint)

W — Junction bead section

W1 — Leader

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[Translation done.]

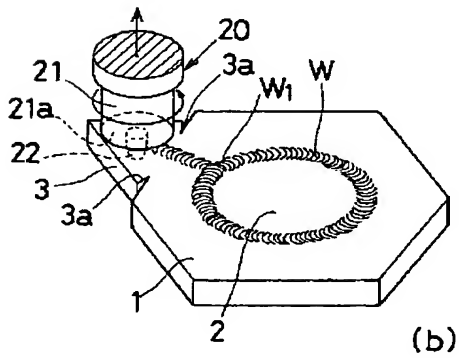
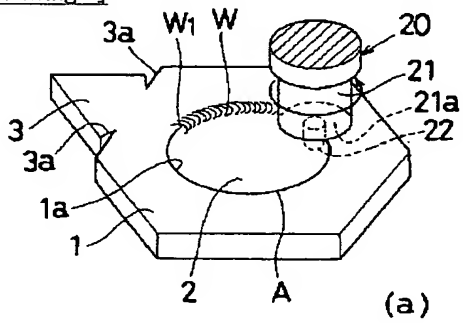
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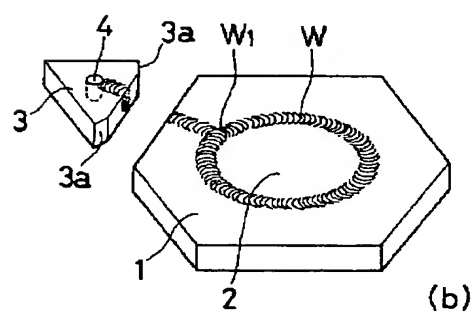
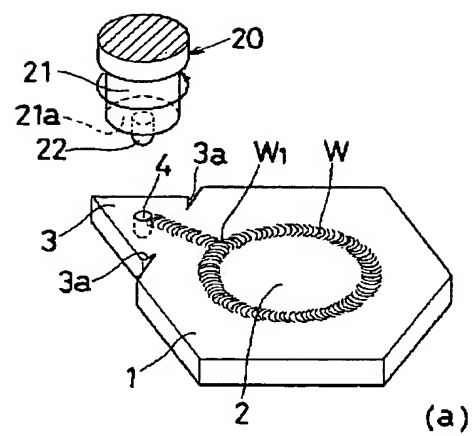
## DRAWINGS

[Drawing 1]

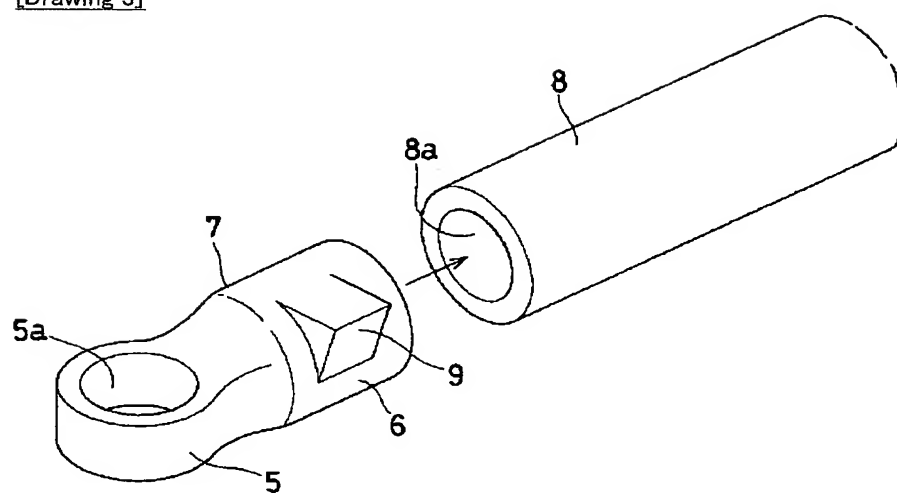


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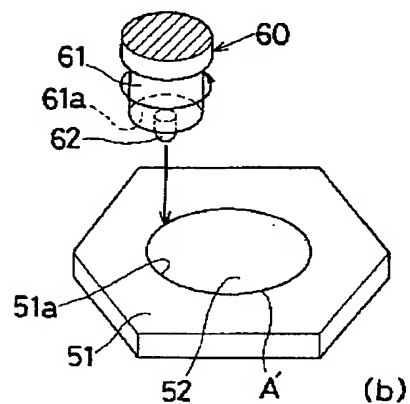
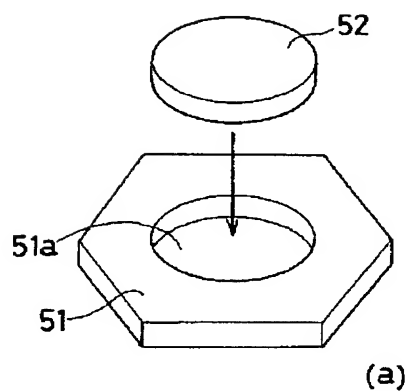




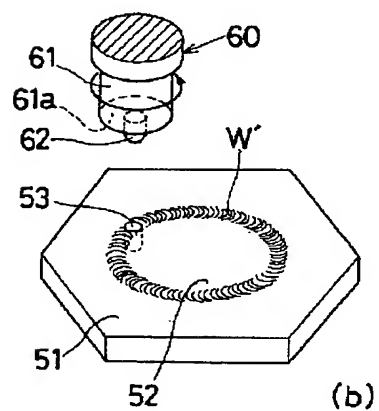
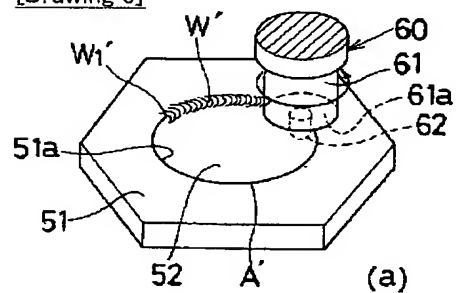
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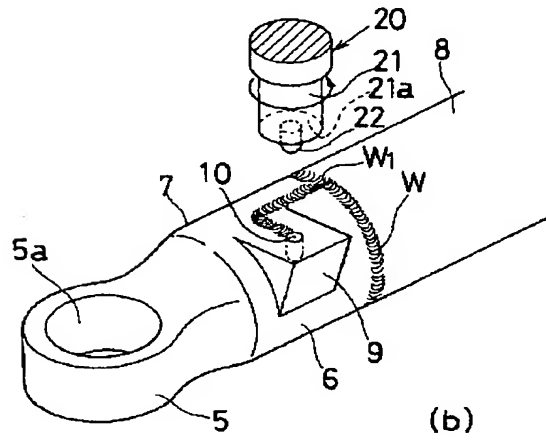
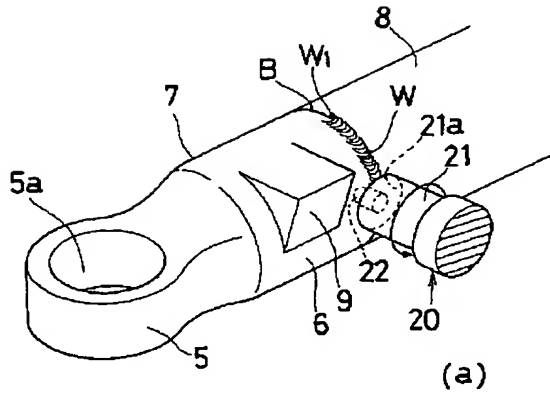
[Drawing 5]



[Drawing 6]



[Drawing 4]



[Translation done.]

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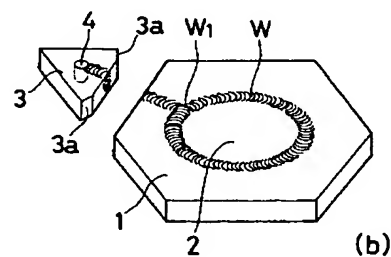
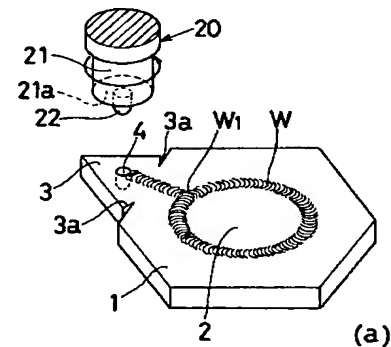
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(54) 【発明の名称】 摩擦撈拌接合法

## (57) 【要約】

【課題】 終端部が始端部に戻るような接合部を有する接合部材を接合する摩擦撈拌接合法において、プローブ引抜き後の孔や凹部を生じさせない摩擦撈拌接合法を提供すること。

【解決手段】 回転するプローブ22を接合部材1、2の接合部Aに挿入し、プローブとの接触部を摩擦熱にて軟化させ撈拌しながら、プローブ22を挿入状態で接合部Aに沿って移動させる。プローブ22が接合始端部W1に戻ってきたら、その移動方向を変えて、プローブ22を接合部材1、2の接合部A以外の位置に設けられた捨て肉部3に移動させる。そして、プローブ22を捨て肉部3から引き抜いた後、この捨て肉部3を切断除去する。



## 【特許請求の範囲】

【請求項 1】 終端部が始端部に戻るような接合部

(A) (B) を有する接合部材 (1) (2) (7)

(8) における前記接合部に、回転するプローブ (22) を挿入し、プローブとの接触部を摩擦熱にて軟化させ攪拌しながら、プローブ (22) を挿入状態で前記接合部に沿って相対的に移動させることにより、前記接合部材を接合する摩擦攪拌接合法において、接合終了時に、前記挿入状態のプローブ (22) を、その移動方向を変えて、前記接合部材の接合部以外の位置に設けられた捨て肉部 (3) (9) に移動させることを特徴とする摩擦攪拌接合法。

## 【発明の詳細な説明】

【0001】

【発明の属する技術分野】この発明は、例えばアルミニウム材（アルミニウム合金材を含む）等の金属材の接合に用いられる摩擦攪拌接合法に関する。

【0002】

【従来の技術】例えば、図 5 に示すように、六角形に形成された板状の金属製第 1 接合部材 (51) の中央に設けられた円形孔 (51a) に、円板状の金属製第 2 接合部材 (52) を嵌合して、第 1 接合部材 (51) と第 2 接合部材 (52) とを嵌合部 (A') の全周に亘って接合する場合には、固相接合法の一つである摩擦攪拌接合法が用いられることがある。

【0003】この摩擦攪拌接合法を説明すれば、次の通りである。即ち、図 5 (b) に示すように、径大の円柱状回転子 (61) の端部軸線上に径小のピン状プローブ (62) が突出して一体に設けられた接合工具 (60) を用い、前記回転子 (61) を回転させつつ、第 1 接合部材 (51) と第 2 接合部材 (52) との嵌合部 (A') の一部に前記プローブ (62) を挿入する。挿入は、一般には、回転子 (61) のプローブ側平坦面からなる肩部 (61a) が両接合部材 (51) (52) に当接するまで行う。

【0004】そして、図 6 (a) に示すように、プローブ挿入状態のまま嵌合部 (A') に沿ってプローブ (62) を両接合部材 (51) (52) に対し相対的に移動させる。プローブ (62) の回転により発生する摩擦熱、あるいは更に回転子 (61) の肩部 (61a) と両接合部材 (51) (52) との摺動に伴い発生する摩擦熱により、プローブ (62) との接触部分近傍において両接合部材 (51) (52) は軟化しかつプローブ (62) により攪拌されるとともに、プローブ (62) の移動に伴って、軟化攪拌部分がプローブ (62) の進行圧力を受けてプローブの通過溝を埋めるようにプローブ (62) の進行方向後方へと回り込む態様で塑性流動したのち摩擦熱を急速に失って冷却固化される。この現象がプローブ (62) の移動に伴って順次繰り返されていき、最終的に両接合部材 (51) (52) が嵌合部

(A') において接合されるものである。同図において、(W') はこの摩擦攪拌接合によって形成された接合ビード部で、嵌合部 (A') に沿って形成されている。

【0005】このような摩擦攪拌接合法によれば、固相接合であるため、接合部材である金属材の種類に限定されないとか、接合時の熱歪みによる変形が少ない等の利点がある。

【0006】ところで、上記の接合部材 (51) (52) を摩擦攪拌接合する場合において、プローブ (62) が嵌合部 (A') における接合始端部 (W1') に戻ると、それ以上接合する必要があるから、同図 (b) に示すように、プローブ (62) を接合部材 (51) (52) から引き抜かなければならない。

【0007】

【発明が解決しようとする課題】しかしながら、プローブ (62) を接合部材 (51) (52) の表面から軸方向に引き抜くと、嵌合部 (A') の接合終端部には、必ずプローブ (62) の径、挿入深さに対応する孔 (53) が残ってしまう。この孔 (53) は接合強度を局部的に低下させるものであるため、接合終了後に、これを取り除いたり、埋めたりしなければならない。

【0008】この孔処理手段として、孔 (53) にピンを埋め込む方法や、TIG、MIG 等の溶融溶接により孔 (53) に溶融金属を充填する方法が提案されている。しかし、ピンを埋め込む方法は、ピンを機械的な食込みにより固定するだけなので、強度的信頼性が乏しい。また、溶融溶接による方法は、溶接時に発生する溶接熱により接合強度の低下や熱歪みが生じる等の問題がある。

【0009】その他、図示していないが、終端部が始端部に戻らないような接合部、例えば直線状の接合部を有する接合部材を摩擦攪拌接合する場合には、接合部の終端部にエンドタブを取り付けた後、プローブ (62) をエンドタブまで移動させ、次いでこのエンドタブを取り除く方法が有効である。しかしながら、この方法は、上記したような回し接合やあるいは円周接合等、終端部が始端部 (W1') に戻るような接合部を有する接合部材 (51) (52) を接合する場合には、終端部が存在しないので、これを適用することができない。

【0010】また、接合始端部 (W1') に戻ってきた挿入状態のプローブ (62) を、その移動方向を変えて第 1 接合部材 (51) の端面から引き抜くことも考えられ、この場合には、第 1 接合部材 (51) の端面にプローブの引抜き痕として凹部 (図示せず) が形成されることとなるので、得られる接合品の外観が悪くなるという問題が生じる。

【0011】この発明は、このような問題を解決するためになされたもので、終端部が始端部に戻るような接合部を有する接合部材を接合する摩擦攪拌接合法におい

て、プローブ引抜き後の孔や凹部を生じさせない摩擦攪拌接合法を提供することを目的とする。

#### 【0012】

【課題を解決するための手段】上記目的を達成するため、この発明は、終端部が始端部に戻るような接合部を有する接合部材における前記接合部に、回転するプローブを挿入し、プローブとの接触部を摩擦熱にて軟化させ攪拌しながら、プローブを挿入状態で前記接合部に沿って相対的に移動させることにより、前記接合部材を接合する摩擦攪拌接合法において、接合終了時に、前記挿入状態のプローブを、その移動方向を変えて、前記接合部材の接合部以外の位置に設けられた捨て肉部に移動させることを特徴とする。

【0013】これによれば、接合終了時に、挿入状態のプローブの移動方向を変えることにより、プローブの移動方向が、接合部の伸びる方向即ち接合線方向からずれることとなる。そして、このプローブを捨て肉部に進入させると、捨て肉部におけるプローブとの接触軟化部分が後方へと塑性流動して、プローブの通過後に生じる溝が埋められる。次いで、捨て肉部に移動した挿入状態のプローブを、捨て肉部から引き抜く。こうすることにより、接合部にプローブ引抜き後の孔が残存しなくなり、したがって接合部の接合強度の低下を防止することができるし、接合部の強度的信頼性も向上する。その後、更に、捨て肉部を除去することにより、接合部材にプローブ引抜き後の孔や凹部が残存しなくなり、したがってプローブ引抜き後の孔や凹部により生じる接合品の外観体裁の低下を防止でき、そのため接合品の外観を維持することができるようになる。

【0014】ここで、捨て肉部は、接合部以外の位置に設けられていればどこでも良いが、接合部の終端部近傍、即ち始端部近傍に設けられていることが、プローブの捨て肉部への移動距離を短くし得てプローブを速やかに捨て肉部に移動させることができ、その結果、接合作業能率を向上させることができるようになる点で、好ましい。

#### 【0015】

【発明の実施の形態】図1及び図2は、この発明の一つの実施形態（第1実施形態）を示すものである。同図において、(1)は六角形に形成された板状の第1接合部材、(2)は円板状の第2接合部材である。これら第1及び第2接合部材(1)(2)はともにアルミニウムからなる。

【0016】前記第1接合部材(1)の中央部には、上記従来技術で説明した第1接合部材(51)と同様に、厚さ方向に貫通した円形孔(1a)が設けられている。同図に示した第1実施形態は、上記従来技術と同じく、この第1接合部材(1)の円形孔(1a)に、前記第2接合部材(2)を嵌合して、第1接合部材(1)と第2接合部材(2)とを嵌合部(A)の全周に亘って摩擦攪

拌接合する場合を示すものである。したがって、嵌合部(A)が両接合部材(1)(2)の接合部となる。なお、第1接合部材(1)と第2接合部材(2)の厚さは同じである。そして、第1接合部材(1)の円形孔(1a)に第2接合部材(2)を嵌合した状態において、第1接合部材(1)の表面と第2接合部材(2)の表面とは面一となっている。

【0017】(20)は接合工具であって、径大の円柱状回転子(21)の端部軸線上に径小のピン状プローブ(22)が突出して一体に設けられているもので、回転子(21)を高速回転させることによりプローブ(22)も高速回転するものとなされている。なお、プローブ(22)及び回転子(21)は、接合部材(1)(2)よりも硬質でかつ接合時に発生する摩擦熱に耐える耐熱材料によって形成されている。

【0018】前記第1接合部材(1)の一端縁には、三角形に形成された板状の捨て肉部(3)が一体に突設されている。この捨て肉部(3)は、後述するように、第1接合部材(1)にプローブ(22)の引抜き孔や凹部を残さなくするためのもので、その厚さは第1接合部材(1)の厚さと同じであり、その表面と第1接合部材(1)の表面とは面一となっている。また、この捨て肉部(3)における第1接合部材(1)との連結部両側縁には、V字状の切込み部(3a)(3a)が設けられ、捨て肉部(3)の除去を容易に行うことができるようになっている。

【0019】この発明に従う摩擦攪拌接合は次のようにして行う。即ち、回転子(21)を回転させることによりこれと一体回転するプローブ(22)を、嵌合部(A)に挿入する。そして、プローブ挿入状態で、回転子(21)の先端の平坦状肩部(21a)を接合部材(1)(2)の表面に当接させるのが、接合開始時あるいは接合途中の軟化部分の素材の飛散を防止しえて均一な接合状態を実現し得るとともに、接合部材(1)(2)と肩部(21a)との摺動により摩擦熱を更に生ぜしめて、プローブとの接触部あるいはその近傍の軟化を促進し、更に接合部材(1)(2)の表面の凹凸形成を防止する点から好ましい。

【0020】そして、プローブ挿入状態のまま、嵌合部(A)に沿ってプローブ(22)を相対的に移動させる。プローブ(22)の回転により発生する摩擦熱、あるいは更に回転子(21)の肩部(21a)と接合部材(1)(2)の表面との摺動に伴い発生する摩擦熱により、プローブ(22)との接触部分近傍において接合部材(1)(2)は軟化しかつ攪拌されるとともに、プローブ(22)の移動に伴って、軟化攪拌部分がプローブ(22)の進行圧力を受けてプローブ(22)の通過溝を埋めるようにプローブ(22)の進行方向後方へと回り込む態様で塑性流動したのち、摩擦熱を急速に失って冷却固化される。この現象がプローブ(22)の移動に

伴って順次繰り返されていき、嵌合部（Ａ）において両接合部材（１）（２）は一体化され順次接合されていく。なお、図１（ａ）において、（Ｗ）はこの摩擦撹拌接合によって形成された接合ビード部で、嵌合部（Ａ）に沿って形成されている。

【００２１】そして、挿入状態のプロープ（２２）が嵌合部（Ａ）における接合始端部（Ｗ１）に戻ってきたとき、両接合部材（１）（２）は嵌合部（Ａ）の全周に亘って接合されたこととなるので、接合終了となるが、このプロープ挿入位置でプロープ（２２）を接合部材

（１）（２）の表面から引き抜くと、上記従来技術で説明したように、プロープの引抜き孔が生じてしまう。そこで、プロープ（２２）の移動方向を変え、図１（ｂ）に示すように、プロープ（２２）を挿入状態のままで捨て肉部（３）に移動させる。このように、プロープ（２２）が捨て肉部（３）に進入すると、捨て肉部（３）におけるプロープ（２２）との接触軟化部分がプロープ（２２）の進行方向後方へと塑性流動して、プロープ（２２）の通過後に生じる溝を埋めることとなる。したがって、嵌合部（Ａ）つまり接合部に孔や凹部が残ること

はない。

【００２２】次いで、こうして捨て肉部（３）に移動したプロープ（２２）を、捨て肉部（３）の表面から軸方向に引き抜く。すると、図２（ａ）に示すように、プロープの引抜き孔（４）が捨て肉部（３）に形成されることとなるので、同図（ｂ）に示すように、この捨て肉部（３）を切込み部（３ａ）（３ａ）において切断除去する。こうすることにより、接合部材（１）（２）におけるプロープ通過跡に孔や凹部が残存しなくなり、そのため接合状態が良好な接合品を得ることができる。

【００２３】なお、図示していないが、捨て肉部（３）に移動したプロープ（２２）を、捨て肉部（３）の端面から引き抜き、次いでその捨て肉部（３）を除去しても良い。

【００２４】また、捨て肉部（３）における第１接合部材（１）との連結部に、予め、破断用の溝（図示せず）を形成しておき、捨て肉部（３）をこの溝において破断することによって、捨て肉部（３）を除去しても良い。こうすることにより、上記第１実施形態と同様に、捨て肉部（３）の除去を容易に行うことができる。

【００２５】図３及び図４は、この発明のもう一つの実施形態（第２実施形態）を示すものである。この第２実施形態は、円形断面を有する２個の接合部材（７）

（８）の円周に沿って行う接合、すなわち円周接合によって、自動車のサスペンションアーム用部材を製作する場合を示している。

【００２６】まず、このサスペンションアーム用部材について説明する。同図において、（８）はサスペンションアーム用部材の部材本体（第２接合部材）、（７）は防振ブッシュ（図示せず）を圧入装着するための円形の

ブッシュ装着孔（５ａ）を有するブッシュ装着部材（第１接合部材）である。前記部材本体（８）は、所定長さを有する棒状のアルミニウム押出円筒パイプ材からなる。（８ａ）はパイプ材の中空部である。また、前記ブッシュ装着部材（７）は、アルミニウム鍛造品からなり、前記ブッシュ装着孔（５ａ）を備えた円筒部（５）の外周面の一部に、円柱状の連結部（６）が一体に突設されているものである。前記連結部（６）の径は、前記部材本体（８）の外径と同寸である。そして、このサスペンションアーム用部材は、図３に示すように、前記部材本体（８）の一端面に、前記ブッシュ装着部材（７）の連結部（６）の端面を突き合わせ、図４に示すように、部材本体（８）とブッシュ装着部材（７）とを突合せ部（Ｂ）の全周に亘って摩擦撹拌接合することによって、製作されるものである。したがって、突合せ部

（Ｂ）が部材本体（８）とブッシュ装着部材（７）の接合部となる。なお、部材本体（８）の一端面に連結部（６）の端面を突き合わせた状態において、部材本体（８）の外周面と連結部（６）の周面とは面一となっている。

【００２７】また、前記ブッシュ装着部材（７）の連結部（６）の周面の一部には、断面三角形状で所定長さを有する凸部からなる捨て肉部（９）が一体に突設されている。この捨て肉部（９）の一面は、連結部（６）の周面と面一となっている。

【００２８】この第２実施形態では、摩擦撹拌接合は上記第１実施形態と略同じ手順で行われ、これを第１実施形態との相違を中心に簡単に説明すると、次の通りである。

【００２９】即ち、前記接合工具（２０）のプロープ（２２）を回転させながら突合せ部（Ｂ）にその外周面から挿入する。そして、プロープ（Ｂ）を挿入状態で突合せ部（Ｂ）に沿って部材本体（８）及び連結部（６）の周方向に相対的に移動させる。この移動に伴って、図４（ａ）に示すように、突合せ部（Ｂ）が順次接合されていく。同図において、（Ｗ）はこの摩擦撹拌接合によって形成された接合ビード部で、突合せ部（Ｂ）に沿って形成されている。

【００３０】そして、挿入状態のプロープ（２２）が突合せ部（Ｂ）における接合始端部（Ｗ１）に戻ってきたとき、接合終了となることから、次いでプロープ（２２）の移動方向を変えて、同図（ｂ）に示すように、プロープ（２２）を挿入状態のままで捨て肉部（９）に移動させる。そして、このプロープ（２２）を捨て肉部（９）の表面から軸方向に引き抜く。なお、図示していないが、プロープ（２２）を捨て肉部（９）の端面から引き抜いても良い。こうしてプロープ（２２）を捨て肉部（９）から引き抜くと、捨て肉部（９）にはプロープの引抜き孔（９）や凹部（図示せず）が形成されることとなる。そして、この捨て肉部（９）を切断除去する。

こうすることによって、ブッシュ装着部材（7）や部材本体（8）におけるプローブ通過跡に孔や凹部が残存しなくなり、そのため接合状態が良好な接合品、即ちサスペンションアーム用部材を得ることができる。

【0031】以上、この発明の第1及び第2実施形態を説明したが、この発明はこれら実施形態に限定されるものではない。

【0032】例えば、上記第1及び第2実施形態では、捨て肉部（3）（9）は接合部材（1）（7）に予め一体に設けられているのであるが、図示していないが、捨て肉部を別途、用意しておき、これを接合部材に取り付けても良い。この取付け手段として、例えば接着剤を用いた接着や押付けを採用することができる。

#### 【0033】

【発明の効果】上述の次第で、この発明は、終端部が始端部に戻るような接合部を有する接合部材における前記接合部に、回転するプローブを挿入し、プローブとの接触部を摩擦熱にて軟化させ攪拌しながら、プローブを挿入状態で前記接合部に沿って相対的に移動させることにより、前記接合部材を接合する摩擦攪拌接合法において、接合終了時に、前記挿入状態のプローブを、その移動方向を変えて、前記接合部材の接合部以外の位置に設けられた捨て肉部に移動させることを特徴とするものであることから、この発明に係る摩擦攪拌接合法によれば、捨て肉部におけるプローブとの接触軟化部分によってプローブの通過後に生じる溝を埋めことができる。したがって、終端部が始端部に戻るような接合部を有する接合部材を摩擦攪拌接合法によって接合する場合であっても、接合部にプローブ引抜き後の孔や凹部が残存しない、つまり接合部の接合強度が高くかつその強度的信頼性も高い接合品を得ることができる。さらに、捨て肉部からプローブを引き抜いた後、この捨て肉部を除去することにより、接合部材にプローブ引抜き後の孔や凹部が残存しない、つまり見栄えの良い接合品を得ることがで

きる。

#### 【図面の簡単な説明】

【図1】この発明の一つの実施形態（第1実施形態）を示す図で、（a）は接合途中の状態の斜視図、（b）はプローブを捨て肉部に移動させた状態の斜視図である。

【図2】同実施形態を示す図で、（a）はプローブを捨て肉部から引き抜いた状態の斜視図、（b）は捨て肉部を切断除去した状態の斜視図である。

【図3】この発明のもう一つの実施形態（第2実施形態）を示す接合前の状態の斜視図である。

【図4】同実施形態を示す図で、（a）は接合途中の状態の斜視図、（b）はプローブを捨て肉部から引き抜いた状態の斜視図である。

【図5】従来の摩擦攪拌接合を示す図で、（a）は2個の接合部材の嵌合前の状態の斜視図、（b）は2個の接合部材の嵌合後の状態の斜視図である。

【図6】従来の摩擦攪拌接合の欠点を示す図で、（a）は接合途中の状態の斜視図、（b）は接合後の状態の斜視図である。

#### 【符号の説明】

1、2…接合部材

3…捨て肉部

4…プローブ引抜き孔

7…サスペンションアーム用部材のブッシュ装着部材（接合部材）

8…部材本体（接合部材）

9…捨て肉部

10…プローブ引抜き孔

20…接合工具

22…プローブ

A…嵌合部（接合部）

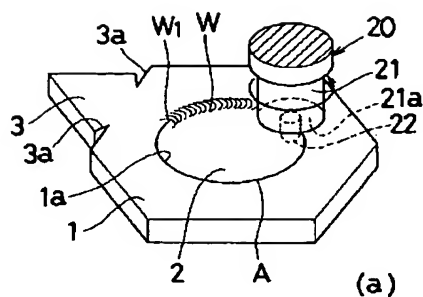
B…突合せ部（接合部）

W…接合ビード部

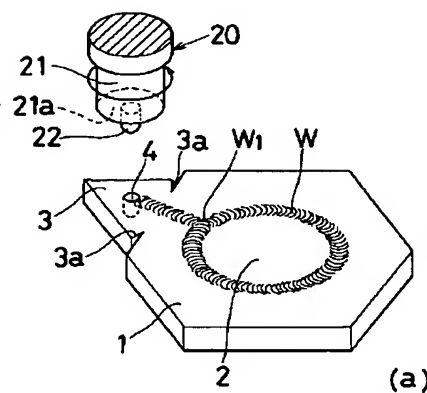
W1…始端部



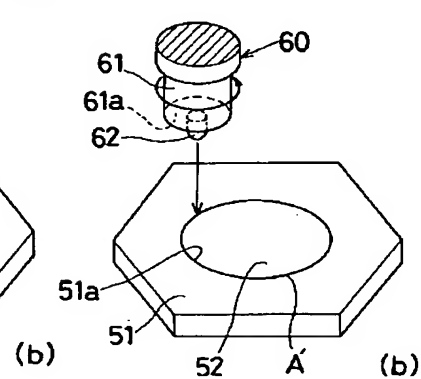
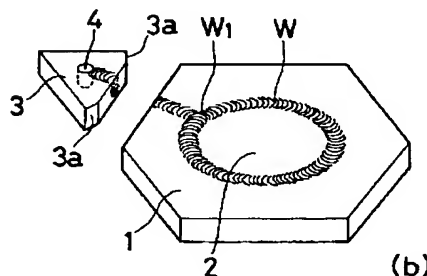
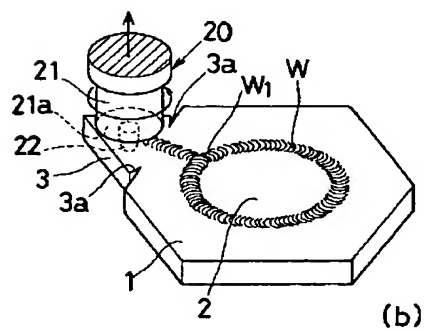
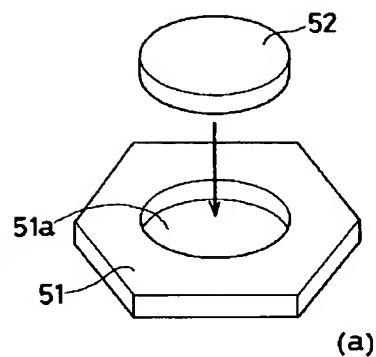
【図 1】



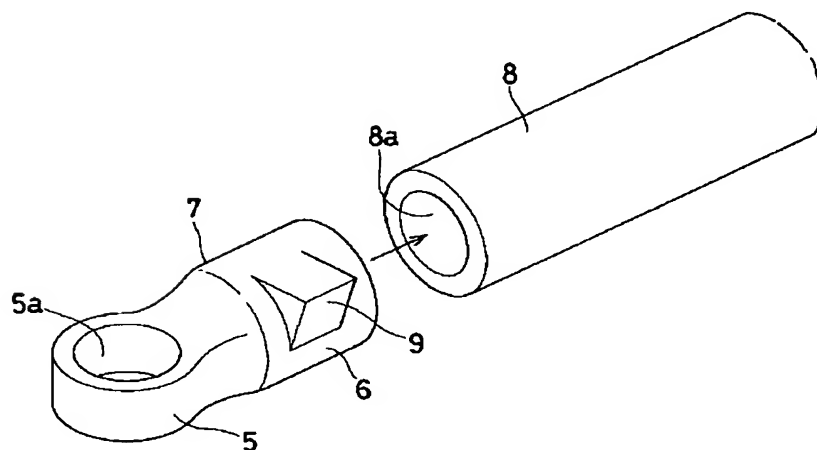
【図 2】



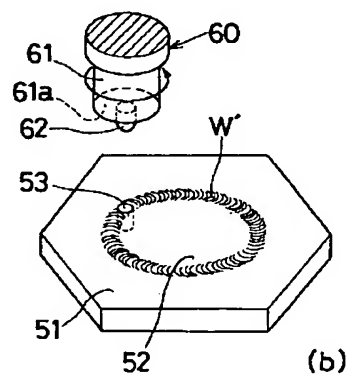
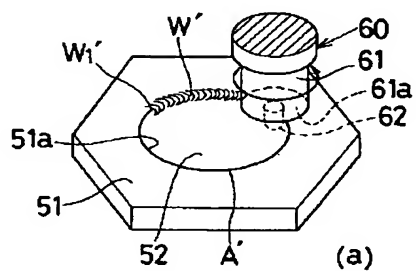
【図 5】



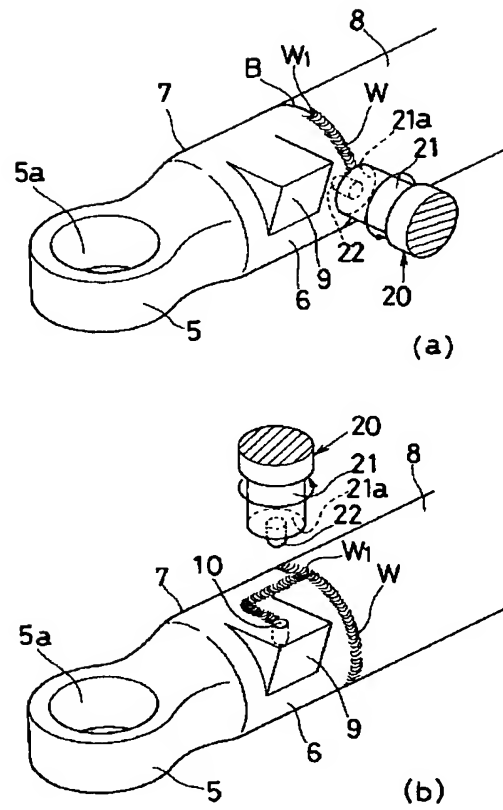
【図 3】



【図 6】



【図 4】



フロントページの続き

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EC01 EC06